

are asked to judge in a signal-detection paradigm whether the sequentially paired stimuli differ. If the predictive compensation were perfect, subject judgments would be correct at the 50% rate expected for random guessing. The procedure is repeated for different levels of added time delay and different predictor compensator designs.

The protocol was employed in two experiments. In the first experiment, one group of subjects compared the baseline VE latency against the output of a generic predictor that compensated for added delays between 16.7 and 100 milliseconds. For the second group of control subjects, these added delays were not compensated in any way. Results (figure 1) show that the generic predictor, even though not tuned to the specific characteristics of the VE system hardware or software, offers benefit at the smaller latencies because its artifacts are less discriminable than the comparable uncompensated control condition delays.

This observation motivated a second study in which three competing predictor designs were evaluated, this time by a single group of subjects. One compensator was the untuned generic predictor from the first study. The second predictor had the same generic design but was tuned for the specific VE system and subject motion task. The third was optimized to minimize jitter artifacts specifically as rendered in a VE head-mounted display. Results (figure 2) indicate that, although tuning the generic filter had little effect, the display-based optimization made the prediction artifacts less discriminable to the subjects. Offline analysis indicates that the improved perceptual characteristics of the display-based optimization are due to its ability to predict slower volitional motion, while at the same time, unlike the other predictor designs, not magnifying high-frequency jitter.

It is important to note that though predictive compensation can diminish the perceptibility of VE latency, the designs tested have not yet attained the 50% discrimination level of "perceptually perfect" prediction. Moreover, predictor discriminability increased with the addition of time delay, indicative of the challenges in compensating the longer VE delays that will be associated with Internet and

satellite communication. The experimental assessment procedure described here, however, will serve to guide the development of new VE predictive compensation schemes and ultimately to validate whether these new designs can predict with the desired level of perceptual transparency.

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## **Center for Health Applications of Aerospace Related Technologies (CHAART)**

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The goal of the Center for Health Applications of Aerospace Related Technologies (CHAART) is to promote the application of remote sensing (RS), geographic information systems (GIS), and related technologies to issues of human health through education, training, and technology transfer. The primary focus of CHAART in FY99 was to support existing, and develop new, collaborations in the application of RS/GIS to studies of human health and surveillance of infectious diseases.

In FY99, CHAART completed another round in the training program for human health investigators. The goals of the training program have been to support human health investigators who integrate RS/GIS into their existing studies, and to facilitate the transfer of RS/GIS technologies to develop sustainable within-country capabilities. With these goals in mind, CHAART participated in several studies of remote sensing of various parasitic and infectious diseases around the world. At the end of FY99, CHAART had received new requests for RS/GIS training from investigators in India, Japan, Korea, Ghana, Ethiopia, Mali, Brazil, and the United Kingdom.

Members of the CHAART staff continued to collaborate with other investigators on the applica-

tion of RS/GIS to specific disease issues through Interagency Agreements with the National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and university investigators. The collaborative applications of CHAART technologies include development of a national risk map for Lyme disease in the Northeastern U.S.; effects of climate change on both Lyme and Hantavirus in the U.S.; ecology of malaria vectors in Kenya; and cholera in Bangladesh and Latin America.

In addition, a new RS/GIS training collaboration in health applications is being developed with the World Health Organization's (WHO's) Special Programme for Research and Training in Tropical Diseases (TDR). This is an outgrowth of the 1995 joint TDR/CDC/NASA training workshop in Guatemala, the 1998 workshop in China, and the 1999 UNISPACE III conference in Austria. CHAART investigators continue to collaborate with the United Nations (UN)/WHO interagency Roll Back Malaria and HealthMap programs. A series of meetings were also held between representatives of the World Bank's AFTH-2, CHAART, and NASA Headquarters, Life Sciences Division to define the goals and objectives of the NASA/World Bank collaboration. This collaboration will also include participation by WHO's HealthMap group. An agreement between NASA's Ames Research Center and the World Bank's AFTH-2 program is currently under development and is expected to be signed in early 2000. New opportunities in training are also being discussed with NOAA (climate variability and health) and the USGS (database development and integration in health planning and surveillance).

NASA CHAART also participated in the development of a National Science Foundation (NSF)/NIH interagency Request for Proposals on the Ecology of Disease. The role of CHAART will be to provide RS/GIS training in support of funded research proposals. Discussions continue between CHAART and the staff of the U.S. Embassy to develop a U.S./Japan collaboration in RS/GIS and health.

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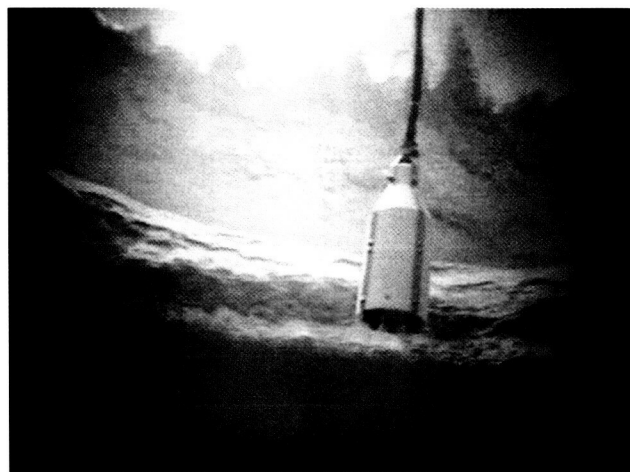
#### ASTROBIOLOGY IMPLEMENTATION

## Geothermal Springs Camera and Sensor Probe

**Jonathan Trent, John W. Hines, Charlie Friedericks, Richard Daily**

The Geothermal Springs Camera and Sensor Probe (aka Mini Monster Cam) is a research instrument developed to support the search for life in extreme temperatures. The purpose of the probe is to find and observe eukarya (multicell organisms) in the depths of geothermal hot springs. Although we know that single-cell organisms proliferate in hot springs, the probe will help prove or disprove the existence of eukarya (Mini Monsters) that might feed on the single-cell organisms. This work is part of a larger effort to define the limits of life on Earth to help narrow the search for life on other planets. During a deployment to Yellowstone National Park (see figure 1), the probe was lowered 60 feet into geothermal springs with temperatures up to 120 degrees Celsius.

The 5-inch-diameter probe holds two underwater cameras, a dissolved oxygen sensor, a pH and temperature sensor, and a pressure (depth) sensor. Each camera and sensor has a 100-foot cable; this setup and a steel pull cable are covered with a plastic sheath for ease of handling. The sensors and cameras are connected to an instrument case that contains the system batteries, two digital video monitor/recorders,



*Fig. 1. The probe enters a hot spring at Yellowstone.*